Exemption No. 8329A

UNITED STATES OF AMERICA
DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
RENTON, WASHINGTON 98055-4056

In the matter of the petition of **THE BOEING COMPANY** for an exemption from §§ 25.301, 25.303, 25.305, and 25.901(c) of Title 14, Code of Federal Regulations	**Regulatory Docket No. FAA-2004-17909**

TIME LIMITED PARTIAL GRANT OF EXEMPTION

By letter dated May 12, 2004, Mr. D. B. Marcrander, Manager, Airplane Certification, The Boeing Company, P.O. Box 3707, Seattle, Washington 98124-2207, petitioned for a time limited exemption from the requirements of §§ 25.301, 25.303, 25.305, and 25.901(c) of Title 14, Code of Federal Regulations (14 CFR) on Boeing Model 777 airplanes equipped with Pratt & Whitney, General Electric, and Rolls Royce engines. To avoid disruption of air commerce, the FAA granted Exemption No. 8329 on May 26, 2004, for the first affected derivative design. This amendment to Exemption No. 8329, if granted, would expand the applicability of the exemption to that originally requested by the petitioner.

The petitioner requires relief from the following regulation(s):

> **Section 25.301** "Loads," which requires:
> " (a) Strength requirements are specified in terms of limit loads (the maximum loads to be expected in service) and ultimate loads (limit loads multiplied by prescribed factors of safety). Unless otherwise provided, prescribed loads are limit loads.
> (b) Unless otherwise provided, the specified air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the airplane. These loads must be distributed to conservatively approximate or closely represent actual conditions. Methods used to determine load intensities and distribution must be validated by flight load measurement unless the methods used for determining those loading conditions are shown to be reliable.
> (c) If deflections under load would significantly change the distribution of

external or internal loads, this redistribution must be taken into account."

Section 25.303 "Factor of Safety," which requires:
"Unless otherwise specified, a factor of safety of 1.5 must be applied to the prescribed limit load which are considered external loads on the structure. When a loading condition is prescribed in terms of ultimate loads, a factor of safety need not be applied unless otherwise specified."

Section 25.305 "Strength and Deformation," which requires:
" (a) The structure must be able to support limit loads without any detrimental permanent deformation. At any load up to limit loads the deformation may not interfere with safe operation.

(b) The structure must be able to support ultimate loads without failure for at least 3 seconds. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the 3-second limit does not apply. Static tests conducted to ultimate load must include the ultimate deflections and ultimate deformation induced by the loading. When analytical methods are used to show compliance with the ultimate load strength requirements, it must be shown that--

(1) The effects of deformation are not significant;

(2) The deformations involved are fully accounted for in the analysis; or

(3) The methods and assumptions used are sufficient to cover the effects of these deformations.

(c) Where structural flexibility is such that any rate of load application likely to occur in the operating conditions might produce transient stresses appreciably higher than those corresponding to static loads, the effects of this rate of application must be considered.

(d) **[**Reserved**.]**

(e) The airplane must be designed to withstand any vibration and buffeting that might occur in any likely operating condition up to V_D/M_D, including stall and probable inadvertent excursions beyond the boundaries of the buffet onset envelope. This must be shown by analysis, flight tests, or other tests found necessary by the Administrator.

(f) Unless shown to be extremely improbable, the airplane must be designed to withstand any forced structural vibration resulting from any failure, malfunction or adverse condition in the flight control system. These must be considered limit loads and must be investigated at airspeeds up to V_C/M_C."

Section 25.901(c) "Installation," which requires:
"For each powerplant and auxiliary power unit installation, it must be established that no single failure or malfunction or probable combination of failures will jeopardize the safe operation of the airplane except that the failure of structural elements need not be considered if the probability of such failure is extremely remote."

The petitioner's supportive information is as follows:

"On June 23, 2003, a GE90-115B thrust reverser inner wall failed during a high power RTO [Rejected Take Off] on a test stand at the General Electric Aircraft Engine facility in Peebles, Ohio. Subsequent investigation of this event revealed previously unrecognized critical aspects of an existing load case. The specific load case occurs at partially deployed conditions during an RTO. The primary cause of the GE90-115B failure was attributed to excessive radial deflection of the v-blade located at the forward edge of the inner wall panel."

"The analysis required to address the newly discovered design requirement is complicated and time consuming. The amount of time needed to demonstrate that these airplanes are compliant to 14 CFR 25.301, 25.303, 25.305, and 25.901(c) exceeds the amount of time prior to delivery. These airplanes must certify major changes to the thrust reverser that do not affect the strength or stiffness, but will require a compliance finding for 14 CFR 25.301, 25.303, 25.305, and 25.901(c). For example, one change involves the incorporation of a new honeycomb core material to replace one that is no longer available. (This change has previously been certified on the PW-powered Model 777-300, but is now being incorporated on the Model 777-200). Parts and assemblies for this and other major changes are already embedded in the production line."

"Models 777PW and 777RR thrust reversers cannot currently be shown compliant for static strength requirements (14 CFR Parts 25.301, 25.303, 25.305) for the loading that occurs as they deploy during an RTO. Structural analysis has shown the Models 777PW and 777RR thrust reversers to be safe, as both have positive margins of safety for the worst case limit load. The GE90-94B thrust reversers have been shown to have positive margins for ultimate load (including a safety factor of 1.5) Note: the v-blade deflection is only an issue for the RTO combined with system failures."

"Compliance cannot currently be shown for v-blade deflection or thrust reverser strength for RTO loading combined with failure conditions (burst duct, failed open Fan Air Modulating Valve (FAMV), or failed closed Pressure Relief Shut Off Valve (PRSOV) for the Models 777PW, 777RR and 777GE90-94B thrust reversers (14 CFR 25.901(c)). However, these thrust reversers have been shown to be safe by acceptably low probability of occurrence (9.2 E-10 occurrences per flight). This position has been confirmed through a formal review by the Boeing Safety Review Board, which voted this issue "Not Safety"."

"The major changes that are planned for these airplanes have no effect on the strength or deflection of the inner wall panel."

"The airplanes have been shown to be safe. Structural analysis has been completed which demonstrates that the airplanes are safe for normal operating conditions. Safety for failure conditions has been demonstrated by probability analysis."

"All models of the Model 777 thrust reverser have successfully passed the 225 cycle endurance test."

"The fleet of PW, RR, and GE90 powered Model 777 airplanes have logged over 1,810,000 flights with over 200 RTOs without incidents or failures of the thrust reversers."

"Boeing has aggressively pursued the new knowledge gained from the Model 777-300ER GE90-115B program and extensive analysis of other thrust reverser installations, and kept the FAA informed throughout the investigation. This petition is being filed only after other certification avenues for timely resolution have been exhausted."

"The airplanes could be delivered with the thrust reversers locked out. However, public safety is enhanced by allowing the continued deliveries of airplanes with fully functional thrust reversers."

"Boeing requests that this exemption be granted by May 21, 2004, in accordance with the provisions of 14 CFR Part 11.87 allowing for rapid approval of exemptions if good cause is shown in the petition. Timely response to this petition will enhance fleet safety by allowing delivery of airplanes with fully operational thrust reversers."

"A delay will have significant adverse impact on The Boeing Company as deliveries of the Model 777 airplanes will be disrupted."

"Boeing expects to show compliance to 14 CFR 25.301, 25.303, 25.305, and 25.901(c) or have a plan to address future deliveries and the delivered fleet no later than May 1, 2005."

"The cost of requiring PW, RR, and GE90 powered Model 777 airplanes to comply with 14 CFR 25.301, 25.303, 25.305, and 25.901(c) prior to the upcoming deliveries is significant. It is Boeing's belief that requiring compliance does not provide a level of safety improvement commensurate with the cost and hence it is not in the best interest of the public."

Notice and Public Procedure Provided

In granting Exemption Number 8329 on May 26, 2004, the FAA waived the requirement for Federal Register publication because any delay in acting on this petition as it related to the first affected derivative design would have been detrimental to The Boeing Company and disruptive to air commerce. However, a summary of this petition was published in the Federal Register (69 FR 30985) on June 1, 2004, soliciting public comment by June 21, 2004. No comments were received.

The FAA's analysis is as follows:

Background

As noted by the petitioner, "On June 23, 2003, a GE90-115B thrust reverser inner wall failed during a high power RTO on a test stand at the General Electric Aircraft Engine facility in Peebles, Ohio. Subsequent investigation of this event revealed previously unrecognized critical aspects of an existing load case. The specific load case occurs at partially deployed conditions during an RTO. The primary cause of the GE90-115B failure was attributed to excessive radial deflection of the v-blade located at the forward edge of the inner wall panel." The loading associated with the blocker doors being extended into the fan stream at high engine power caused deflection of the v-blade. The deflection was great enough to result in local disengagement, and fan air passed under the v-blade and pressurized the core compartment. This pressurization of the core compartment put loads on the thrust reverser inner wall that had not previously been considered. These loads, combined with the loading from the blocker doors, caused failure of the inner wall panels to which the blocker door links were attached.

While the GE90-115B thrust reverser design was modified to prevent such a failure prior to certification, there is recognition that other existing and proposed thrust reverser designs may be susceptible to a similar failure mode. Consequently, any "finding of compliance" must now consider this possibility. Anticipated system failures that could result in core compartment pressurization must also be considered (e.g., failure of a bleed duct; the fan air valve failed or locked open; or the pressure relief and shutoff valve failed or locked closed).

Failure of the thrust reverser inner wall panels can cause loss of the blocker door link restraints, which in turn leads to loss of the blocker doors thrust reversing capability. Hence, the affected engine would produce high power forward thrust when high power reverser thrust is commanded. Since the translating sleeve would still deploy, the flight deck displays would indicate the reverser has deployed. The first flight deck indication of the failure would be the lateral directional control problem associated with the thrust asymmetry from having high forward thrust on one engine and high reverse thrust on the other engine. This could lead to a runway departure, especially when the RTO was initiated at high speed on a contaminated runway.

Introduction

Several thrust reverser design modifications are scheduled to be type certificated and incorporated into Boeing Model 777 airplane production within the next six months. Recent recognition of conditions which could affect compliance with the subject regulations as they relate to the structural strength, deformation, and failure of thrust reverser inner wall panels has necessitated development and validation of substantially new finite element structural models and analyses for these proposed derivative thrust reversers. This means that compliance with the subject regulations cannot be completely demonstrated in time to support the scheduled deliveries of affected production airplanes. The planned changes, which are known to require a relevant new finding of compliance, involve replacing thrust reverser inner wall core materials that are no longer available, with new core materials. The FAA has determined that replacing the core material should not make the derivative designs any more susceptible to failure of the inner wall panels than are the existing designs from which they were derived. Although FAA regulations would allow certification of the affected Boeing Model 777 airplanes without operational thrust reversers, the FAA considers it to be safer to certificate these airplanes with operational thrust reversers, even though strict compliance with the subject regulations has not yet been demonstrated. The implication of the recently discovered loading conditions for the thrust reverser designs already in service is also being investigated. The FAA does not currently consider these implications to be serious enough to warrant an airworthiness directive. However, if subsequent information indicates some mitigating or corrective action is warranted, that action will be taken.

This time limited partial grant of exemption permits type certification of Boeing Model 777 airplanes with derivative thrust reverser designs covered by the petition without showing strict compliance with the referenced regulations. One example of the relevant thrust reverser modifications, which are the subject of this exemption, are those whereby a new core material replaces one which is no longer available. Such a change was approved for the Pratt & Whitney engine installation on the Boeing Model 777-300 airplanes before these new loading cases were recognized. The same change was approved under Exemption Number 8329 for the Boeing Model 777-200. The petitioner states and the FAA agrees that these modifications have no effect on the strength or deflection of the inner wall panels. Other changes similar in scope are planned for the different thrust reverser designs installed on the Boeing Model 777 airplanes.

To receive a time limited exemption, the petitioner must show, as required by § 11.81(d), that granting the request is in the public interest, and, as required by § 11.81(e), that the exemption will not adversely affect safety, or that a level of safety will be provided that is equal to that provided by the rules from which the exemption is sought.

Public Interest

If the FAA were to deny this petition, the only timely alternative for the petitioner would be to certificate and try to deliver the affected airplanes with both thrust reversers deactivated. The associated performance penalty for operations on wet or otherwise contaminated runways would probably be around 5% of field length. This would likely result in customers either not taking delivery or demanding substantial compensation to take delivery of the affected airplanes. Further, the safety provided by operational reversers could never be completely compensated for by performance penalties. For example, these penalties would not compensate for the loss of the ability to use asymmetric reverse thrust to compensate for braking, steering or aerodynamic asymmetries during high speed ground deceleration operations. In the view of both the petitioner and the FAA, the risk posed by the potential non-compliance allowed by granting this time limited partial grant of exemption is much less than the risk that would be posed by certificating without operational thrust reversers.

The only other alternative to this time limited partial grant of exemption would be for the petitioner to wait to deliver the affected airplanes until compliance can be demonstrated. Given the current estimates provided by the petitioner, this would mean delaying delivery of 25 airplanes (8 with Pratt & Whitney engines, 4 with General Electric engines, and 13 with Roll Royce engines) for up to a year. Clearly, this would have an adverse logistical and financial impact on the petitioner, their suppliers, the affected airlines, their employees, and the traveling public. The FAA considers these costs would easily exceed the value of what small safety benefit could be gained by not granting this exemption.

The petitioner will be required by the conditions for granting this time limited partial grant of exemption to report any information they acquire which might invalidate the justifications given for granting this exemption.

In consideration of the above, the FAA concludes that granting this petition is in the public interest.

Effect on Safety

Boeing has committed in their petition to either show compliance or have a plan to address future deliveries and the delivered fleet no later than May 1, 2005.

Given the extensive good service experience of similar designs and what we know about the structural integrity of the subject thrust reveser inner wall, the FAA does not expect this design to be found to be non-compliant. However, to reduce the principle risk within the fleet if this failure mode does exist, the FAA is proposing to further restrict dispatch with failures known to pressurize the engine core compartment on the affected Boeing Model 777 airplanes currently in service.

As a condition for granting this time limited partial grant of exemption, dispatch relief for conditions that could pressurize the core compartment will be restricted to three days. This restriction will be made a type design operating limitation. Since the modified thrust reversers subject to this exemption are not expected to pose any greater risk than those already in service, and there are only twenty five airplanes equipped with these modified thrust reversers scheduled to be delivered during the effective period of this time limited exemption, granting this exemption would have negligible effect on the overall risk posed by this failure condition within the Boeing Model 777 airplane fleet.

The petitioner has indicated that: "The airplanes have been shown to be safe. Structural analysis has been completed which demonstrates that the airplanes are safe for normal operating conditions. Safety for failure conditions has been demonstrated by probability analysis." Submittal of acceptable documentation of these demonstrations to the FAA will be made a condition for granting this exemption.

This time limited partial grant of exemption inherently implies a somewhat greater uncertainty, and hence risk, than demonstrating full compliance with 14 CFR 25.301, 25.303, 25.305, and 25.901(c). Nevertheless, we do not think that the subject designs are non-compliant. Further, the per flight hour risk predicted by the petitioner is very low even if we assume the design is non-compliant.

The petitioner will be required by the conditions for granting this time limited partial grant of exemption to report any information they acquire which might invalidate the justifications given for granting this exemption.

In consideration of the above, the FAA concludes that granting this exemption will not adversely affect safety.

The Partial Grant of Exemption

In consideration of the foregoing, I find that a time limited partial grant of exemption is in the public interest. Therefore, pursuant to the authority contained in 49 U.S.C. 40113 and 44701, delegated to me by the Administrator, The Boeing Company is granted a time limited partial grant of exemption from 14 CFR 25.301, 25.303, 25.305, and 25.901(c) to the extent necessary to allow type certification of the modifications to the thrust reverser type designs of Boeing Model 777 airplanes without a complete showing of compliance. These requirements relate to the structural strength, deformation and failure of the thrust reverser inner wall panels during a rejected takeoff related thrust reverser deployment at high engine power. This time limited partial grant of exemption is subject to the following conditions and limitations:

1. The Boeing Company must report to the FAA any information they acquire which might invalidate the justifications given for granting this exemption.

2. The Type Certificate Data Sheet (TCDS) and Airplane Flight Manual (AFM) must include a type design operating limitation that limits dispatch to three days with any failure condition which could pressurize the core compartment. This includes, but may not be limited to, dispatch with the Fan Air Valve locked open or the Pressure Relief and Shutoff Valve locked closed.

   This dispatch prohibition shall be reviewed by the Flight Operations Evaluations Board (FOEB) for the Boeing Model 777 airplane at the earliest opportunity to consider developing a revision to the Master Minimum Equipment List (MMEL) for all Boeing Model 777 airplanes. This exemption condition, and the associated type design limitations, may be amended based upon the findings of the FOEB or other relevant information obtained subsequent to the date of granting this exemption.

3. Before issuance of the amended type certificate, documentation must be submitted to the FAA which substantiates the petitioner's assertions that: "The airplanes have been shown to be safe. Structural analysis has been completed which demonstrates that the airplanes are safe for normal operating conditions. Safety for failure conditions has been demonstrated by probability analysis."

4. The granting of this partial grant of exemption does not relieve any regulatory obligation to identify and correct unsafe conditions related to thrust reverser inner wall panel failure conditions.

This exemption terminates on May 1, 2005, unless sooner superseded or rescinded. Upon termination of this exemption, any type certification issued by the FAA in consideration of this exemption shall be void unless the Administrator has found compliance with the regulations for which this exemption was granted.

Issued in Renton Washington on July 15, 2004.

/s/ Ali Bahrami
Ali Bahrami
Manager
Transport Airplane Directorate
Aircraft Certification Service